



ENERGY/AIR QUALITY ADVISORY COMMITTEE

October 14, 2011

Robert Hoyt, Director
Department of Environmental Protection
Montgomery County
255 Hungerford Drive
Rockville, MD 20850

Dear Bob,

At our September meeting, we decided that we needed to talk with you about decisions about upcoming code changes that will affect citizens of our county. These changes may adversely affect the health of County residents. It's not obvious that there would be a net energy savings if we adopt both IECC 2012 and IRC 2012 together.

We have presented some of our thoughts to two members of your staff (Stan Edwards, Division Chief Division of Environmental Policy and Compliance, Eric Coffman, Senior Energy Planner) (see accompanying documents), we think that we need to talk with you directly. We will also be seeking a similar meeting with the new head of the Department of Permitting Services. We believe that each of your departments has important responsibilities regarding this topic.

We are seeking this meeting with you sometime in late October. We anticipate that we might need about 60 to 75 minutes.

Sincerely,

Paul Bubbosh, Chair

Attachments: Issues with New Building and Code Choices
Cc: EAQAC, DEP Liaison Staff

Memorandum

To: Members of EAQAC
From: Bernard Bloom
Date: September 15, 2011
Subject: **Issues with New Building and Energy Codes**

This memorandum presents analysis of two of the new codes that shortly will be considered for adoption by Montgomery County. One fundamental conclusion from this analysis, that is made explicit below, is that for some homes these codes imply an increase in cost and decrease in indoor air quality.

1.0 Background

The two codes are the 2012 versions of the International Residential Code (IRC-2012) and the International Energy Conservation Code (IECC-2012). The focus of this memorandum is new homes, although these codes, if adopted, may also apply to some renovated homes. The codes affect indoor air quality because they (1) provide requirements for outside air ventilation and (2) establish building tightness limits (BTLs) for new homes. The two codes have to be read together to understand the overall effect they would have on new home indoor air quality.

An initial and vital fact is that, for the first time, the 2012 version of the IRC requires whole-house mechanical ventilation¹ under certain conditions. In the 2009 version of this code, for instance, the only instance in which any type of mechanical ventilation is required is if a habitable room does not have openable doors or windows that are at least 4% of the room's floor area. If the openable area is present, no mechanical ventilation is required.

But, in the 2012 version of the IRC, whole-house mechanical ventilation is absolutely required even if openable areas are present in each habitable room. The principal criterion that drives whole-house mechanical ventilation is that the house is built tighter than 5 ach @50 PA. This outdoor air exchange rate is approximately equivalent to 0.25 ach, as an annual average, for naturally ventilated homes...

This criterion should be read against the IECC-2012 requirement that new homes shall be tighter than 3 ach @50 PA in our climate zone. This BTL is approximately equivalent to 0.15 ach, as an annual average, for naturally ventilated homes. Taken together, these codes imply that (were they adopted as written by Montgomery County Government) that all new single family homes in the county would have to be equipped with whole-house mechanical ventilation.

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"WHOLE HOUSE MECHANICAL VENTILATION SYSTEM. An exhaust system, supply system, or combination thereof that is designed to mechanically exchange indoor air with outdoor air when operating continuously or through a programmed intermittent schedule to satisfy the whole house ventilation rates."

2.0 Air Quality Implications of these Codes

IRC-2012 requires that if whole-house mechanical ventilation is required, that such a system (or systems in the aggregate) be capable of supplying (as a minimum) the amount of outside air shown in the following table. Units of air flow are in cfm.

Table A

		Minimum Mechanical Airflow (ASHRAE 62.2) and IRC-2012, Table M1507.3.3(1)				
Floor Area, sf min	Floor Area, sf max	No. of Bedrooms + 1				
		2	4	6	8	10
0	1500	30	45	60	30	30
1500	3000	45	60	75	45	45
3000	4500	60	75	90	60	60
4500	6000	75	90	105	75	75
6000	7500	90	105	120	90	90
7500	9000	105	120	135	150	165

Note that the International Codes Council lifted the minimum mechanical outside air flow in their table (IRC-2012, Table M1507.3.3(1)) verbatim from the mechanical air ventilation rate minima contained in the ASHRAE model code for residential ventilation, ASHRAE 62.2. Within the ASHRAE model code is another fact: the model code provides an "infiltration credit" of 2 cfm per 100 sf of occupiable space. That is, the minimum amount of outside air considered by ASHRAE to be acceptable for indoor spaces occupied by people is really greater than the flow rates in the preceding table.

The total amount of outside air stated by ASHRAE to be acceptable for people is given in the next table.

Table B

		NUMBER OF BEDROOMS				
Floor Area, sf min	Floor Area, sf max	0 - 1	2 - 3	4 - 5	6 - 7	> 7
		2	4	6	8	10
		Minimum Healthy Airflow (ASHRAE 62.2)				
0	1500	60	75	90	105	120
1500	3000	105	120	135	150	165
3000	4500	150	165	180	195	210
4500	6000	195	210	225	240	255
6000	7500	240	255	270	285	300
7500	9000	285	300	315	330	345

For naturally ventilated homes that are built to existing tightness limits (0.35 ach in Mo. Co.), the average amount of infiltration air is shown in Table C. Insofar as the values in Table C > than those in Table B, natural ventilation of a 0.5 ach house appears to supply, on the average, sufficient air to satisfy the ASHRAE minimums for single family homes.

Table C

		NUMBER OF BEDROOMS + 1				
Floor Area, sf min	Floor Area, sf max	2	4	6	8	10
Natural Annual Avg. Airflow in CFM for a 0.35 ach House						
0	1500	70	70	70	70	70
1500	3000	140	140	140	140	140
3000	4500	249	249	249	249	249
4500	6000	333	333	333	333	333
6000	7500	416	416	416	416	416
7500	9000	499	499	499	499	499

By the same reasoning, by itself whole-house mechanical ventilation to the 2012 IRC standard (Table A) does not meet the ASHRAE health standard; every value in Table A is less than those shown in Table B. However, this reasoning is incomplete. Natural infiltration does not necessarily cease, just because a whole-house outside air fan is operating. One has to add to the Table A values, the amount of such infiltration.

The mechanical and natural infiltration air flows are not additive. Research has demonstrated that the best estimate of the combined mechanical and natural air flow is given by the following formula, when the mechanical air flow is less than double the natural air flow. This condition does in fact apply to the cases under consideration. This formula is known as the Palmiter "half" rule².

$$(1) Q_{\text{total}} = [Q_{\text{mechanical}} + Q_{\text{natural}}] - 0.5 * Q_{\text{mechanical}}$$

Rewritten, the "half rule" is:

$$(2) Q_{\text{total}} = Q_{\text{natural}} + 0.5 * Q_{\text{mechanical}}$$

When one applies this rule to case under consideration, one obtains the following result for a whole-house mechanically ventilated house at 0.35 ach. Combined mechanical and natural infiltration exceeds the ASHRAE minima for good indoor air quality³.

Table D

		No. of Bedrooms + 1				
Floor Area, sf min	Floor Area, sf max	2	4	6	8	10
% of Min. Outside Air for a 0.35 ach house under whole-house mech. ventilati						
0	1500	142%	123%	small footprint houses don't have 5-9 bedrooms		
1500	3000	155%	142%	131%		
3000	4500	186%	174%	164%		
4500	6000	houses with 2-3 bedrooms		171%	151%	142%
6000	7500	don't have such large		176%	159%	151%
7500	9000	occupied areas		180%	165%	158%

² Palmiter, L, and T. Bond, "Impact of Mechanical Systems on Ventilation and Infiltration in Homes", ACEEE 1992 Summer Study of Energy Efficiency in Buildings

³ Any amount of outside air ventilation, whether by natural and/or mechanical, means cannot provide sufficient dilution and exhaust:

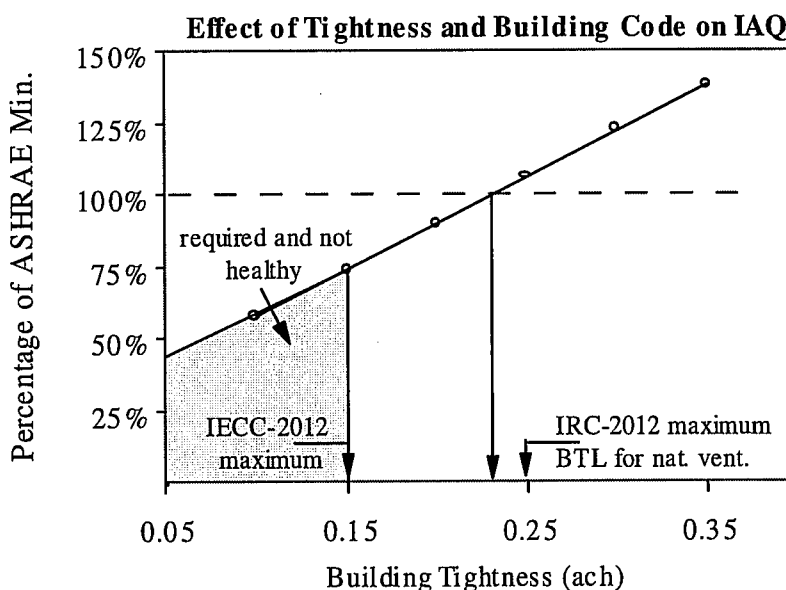
- For people with particular chemical or biological sensitivities
- Inside homes with large sources of airborne chemicals or micro-organisms

As houses become increasingly tighter, however, a limit is reached when this conclusion no longer applies. I have selected an “example house” to demonstrate this effect. The house is defined as follows:

Occupied space:	3000 sf area on 2 levels (9 ft ceilings) + 1000 sf basement (8 ft ceilings) 35,000 cubic feet
Bedrooms	4

Figure shows the relationship between the average total outside air flow and building tightness. Notice that at tightnesses less than 0.20 ach that the amount of outside air falls below the minimum amount of air deemed appropriate for human health, as defined by the ASHRAE 62.2 committee and as accepted by ASHRAE.

Figure 1



The principal reason for this effect is that the amount of mechanical ventilation air specified in Table A was developed by ASHRAE in the early part of the previous decade. Only now has the International Codes Council begun to incorporate requirements for whole-house ventilation. The building tightness standards extant in 2003-2004 were typically 0.35 ach (see for instance IRC-2009).⁴

⁴ Please consider this from Mr. Steve Emmerich, a member of, and former chair of the ASHRAE 62.2 committee. I asked him in a letter dated September 2, 2011 “Could you please comment on whether you think the mechanical ventilation requirements of TABLE M1507.3.3(1) are sufficient for homes built to the 2012 IECC tightness requirements?” His response is “Please consider these responses to be my personal opinion as past Chair of ASHRAE SSPC 62.2 and not official responses of either NIST or ASHRAE. ... As you know, from a Standard 62.2 perspective, those rates are currently considered to be sufficient minimum rates and the current standard does not require increasing them for tighter homes. However, there is active debate among the committee experts on whether the default infiltration credit is still appropriate for new tight homes and should continue to be part of the standard. The committee might consider a change to that portion of the standard in the near future but one can only speculate on what exactly a change might be and when it might become effective.”

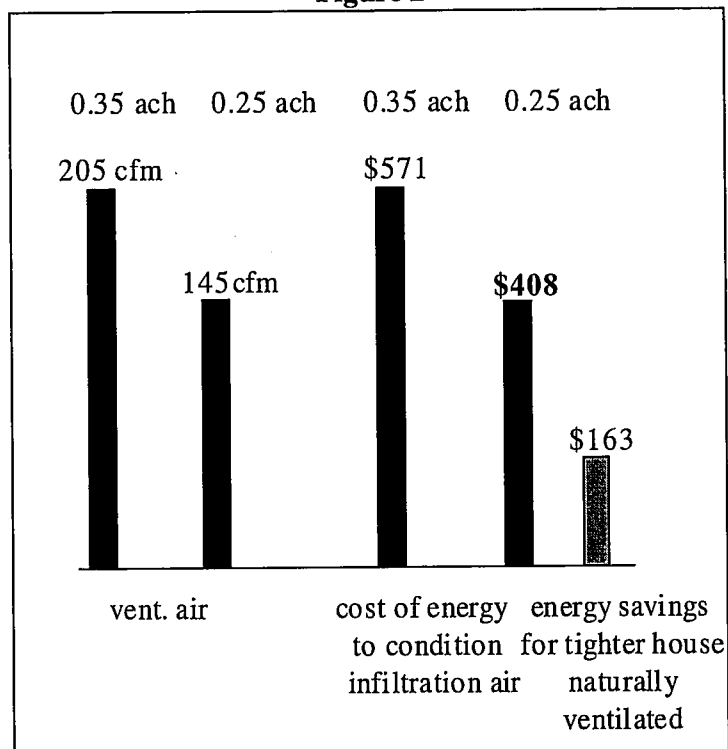
Air Quality Conclusion

The principal conclusion I draw from this analysis is that the simultaneous imposition of a BTL not to exceed 0.15 (IECC-2012) and the requirement for whole-house mechanical ventilation for building tightnesses less than 0.25 ach, would lead to the construction of unhealthy homes.

3.0 Energy Conservation Implications of these Codes

The requirement for whole-house mechanical ventilation has significant, and not necessarily positive, energy conservation implications. It is completely true that the reduction of unneeded natural infiltration air will lead to less natural gas and/or electricity use for space conditioning the unneeded infiltration air. Using the example house again, Figure 2⁵ illustrates this point.

Figure 2



But, this benefit has a severe limit once whole-house mechanical ventilation air is required. This is because the energy savings for the same house tightness must be obtained from heat recovery and heat or energy recovery ventilators require electricity to operate. And, this operation must be considered to occur 8760 hours per year, especially for houses tighter than 0.20 ach. (See Figure 1).

⁵ Figure 2 was calculated from these assumptions: 90% AFUE gas furnace; SEER 14 AC; typical meteorological year for suburban Wash., DC; current utility prices; and indoor/outdoor temperatures of: (winter) 70°F/37° and (summer) 74°/83°F.

These effects are shown in Figure 3. The figure is calculated by assuming a well known ERV manufacturer's specifications for an ERV at face value (i.e., 76% overall sensible and latent heat recovery, 70 watts⁶, current electricity prices in Mo. Co.). The 76% energy recovery figure is optimistic but assumed for the purpose of Figure 3.

Figure 3

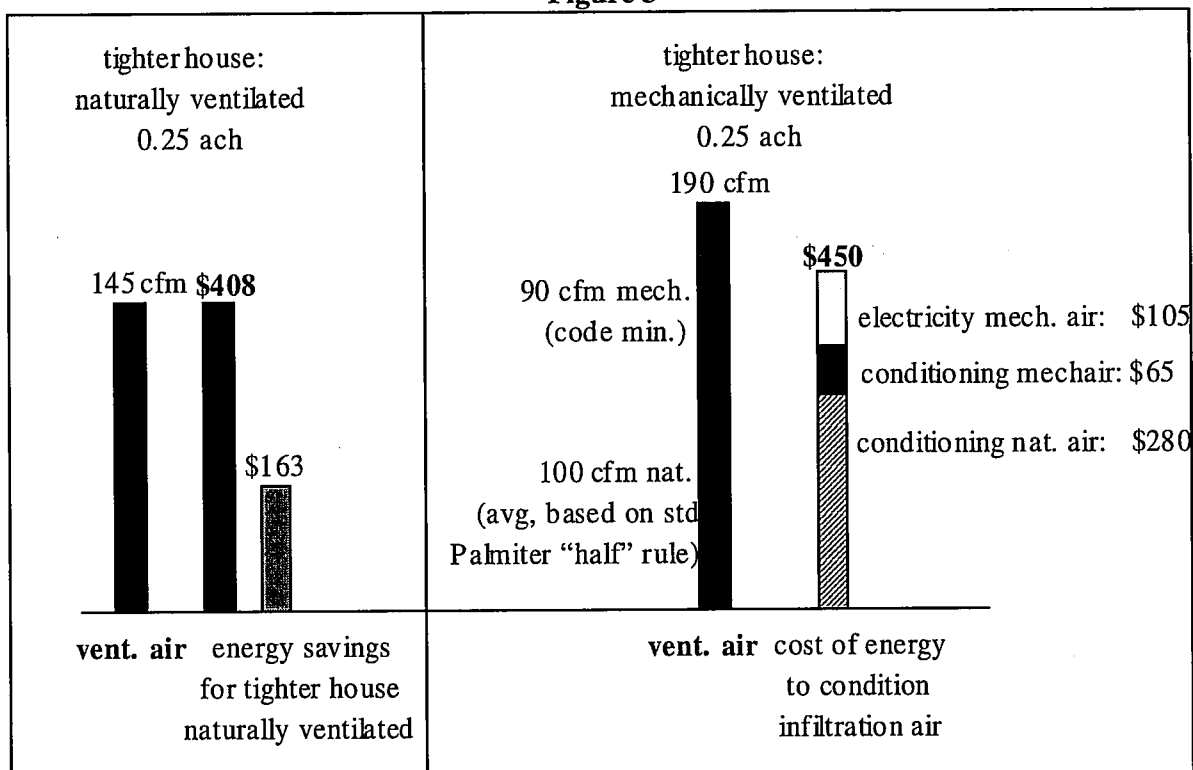
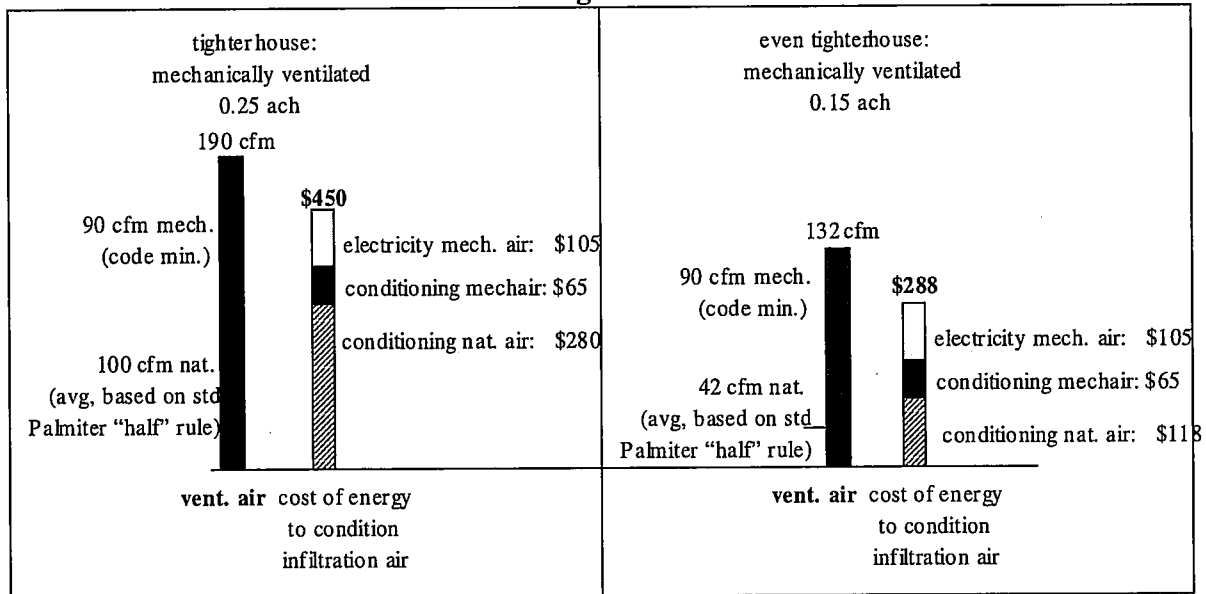


Figure 3 shows that once mechanical ventilation is imposed that the house does not stop being naturally infiltrated. Rather the average infiltration rate decreases from 145 cfm to 100 cfm. For details, see eqn (2). Overall, ventilation air handling, that would cost \$408 in a naturally ventilated home, increases by 10% to \$450 in the mechanically ventilated home.

Figure 4, using the same calculation methods as above, shows the effects of IECC-2012.

⁶ Note: 70 watts is the lowest power level at which such an ERV could operate. The manufacturer's specification states the range to be between 70-150 watts, depending upon the amount of air needed and static pressure (duct layout) details.

Figure 4

The BTL imposed by IECC-2012 reduces natural infiltration rates. IRC-2012 still requires the same amount of mechanical air. The overall effect is to decrease energy costs by 36%, from \$450 to \$288.

Table E summarizes the energy picture.

Table E

Bldg Tightness	Outside Air Vent.	Annual Energy Cost of Vent. Air
0.25 ach	natural	\$408
0.25 ach	mechanical	\$450
0.15 ach	mechanical	\$288

The energy savings reflected in Figure 4 and Table E is based on the installation and operation of an ERV. This technology is not required by either code. Figure 5 demonstrates the critical nature of this technology.

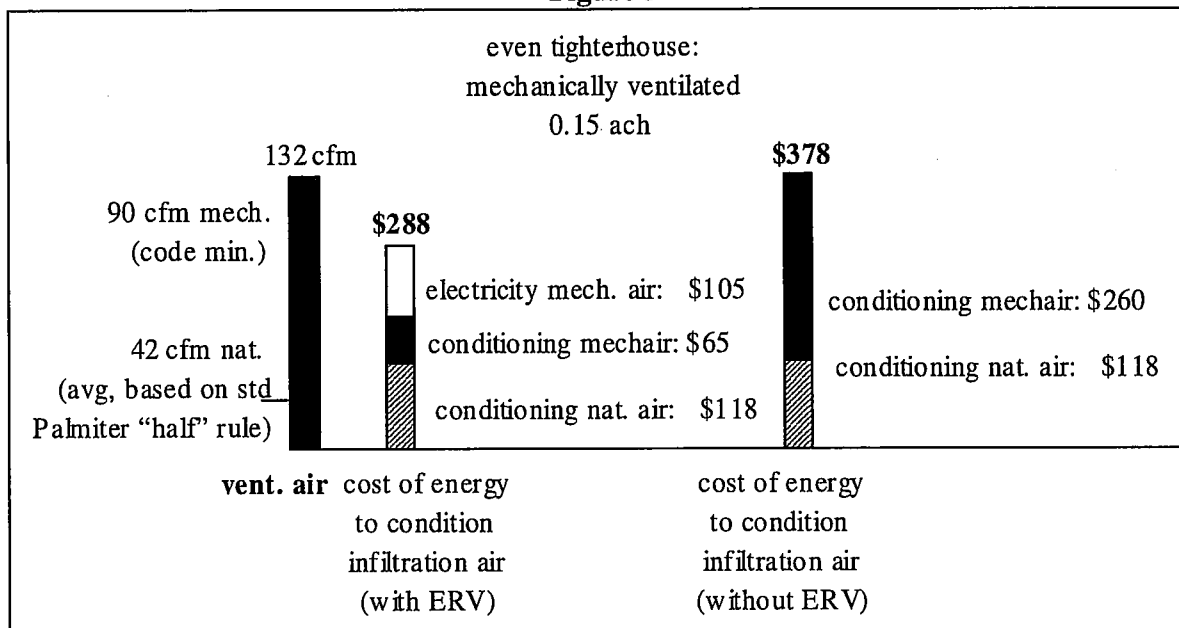
Figure 5

Table E was recomputed to include the fact that ERVs are required by code.

Table F

Bldg Tightness	Outside Air Vent.	Annual Energy Cost of Vent. Air
0.25 ach	natural	\$408
0.25 ach	mechanical	\$450
0.15 ach	mechanical - with ERV	\$288
0.15 ach	mechanical - without ERV	\$378

The key point is that virtually all of the energy savings by requiring homes to be tightened from current code to new code is not achieved if energy recovery ventilators are not installed by builders. The difference in the energy cost for conditioning naturally ventilated outside air and a tight, mechanically ventilated house without energy recovery is only 7%. This difference is not significant within the uncertainties inherent in the calculation methods.

Energy Conservation Conclusions

The conclusions I draw from this analysis is that adoption of both IECC and IRC, as written, will not necessarily save energy over current requirements unless:

- Energy recovery is required and
- Tightness limits are enforced with required blower door tests on every house.

As written, the 2012 codes cannot be relied upon for ventilation-based residential energy savings.

4.0 Overall Summary of Analysis

The results of this analysis suggest two critical points:

1. Acceptable indoor air quality will not be achievable if the county adopts the Building Tightness Limit specified in IECC-2012.
2. Energy savings from a combination of tighter homes and mechanical ventilation only available if county were to require energy recovery. If not, tightening does not result in energy savings over baseline case (approximately, now).

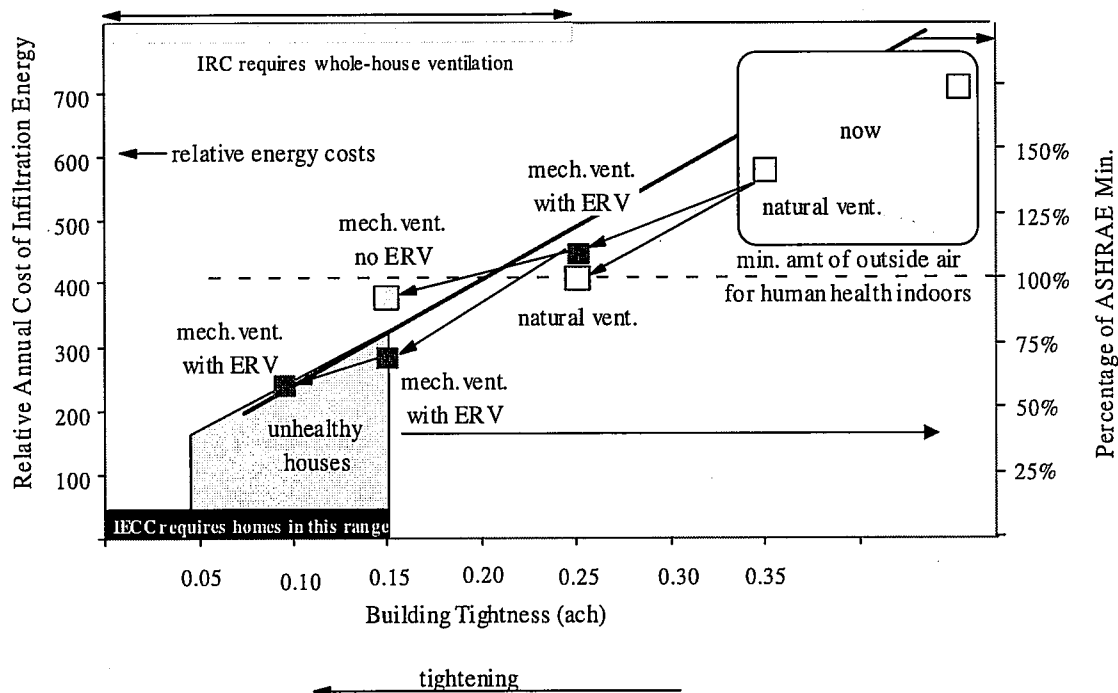
The analysis from which these observations are drawn is depicted in Figure 6. Point 1, above, can be seen in Figure 6 in the area marked “unhealthy houses.” This area is bounded by an upper tightness of 0.15 ach, from IECC-2012. Any energy savings sought in this area means that indoor air quality is compromised.

For the example chosen to illustrate Point 2, above, look at the green squares labeled “mech. vent. With ERV.” Compare to the square labeled “mech. Vent. with no ERV.”

While the details of this figure will vary with specific house configuration, the main ideas are clear:

- A factor of 2+ energy savings is possible if we adopt both codes, but only if we also require energy recovery and if we ignore healthy indoor air quality.
- We can only expect an energy savings of 50% or so if we respect IAQ.

Figure 6



5.0 Discussion of Choices

The following is a partial list of possible choices that the county could discuss.

Choice 1 would be to propose to adopt both codes as is, with respect to building tightness and residential ventilation.

This choice offers the greatest degree of energy savings relative to heating and cooling outside air. It adopts the very tight BTL of IECC-12. But, because these two codes do not require mechanical ventilation systems to employ heat or energy recovery technology, the degree of energy savings cannot be assured.

It requires mechanical ventilation because the BTL (.15 ach) is tighter than the IRC-12 requirement for whole-house mechanical ventilation below 0.25 ach.

This choice will be difficult to meet. During the past fiscal year every tenth home was to have been blower door tested. The results of those tests may suggest to builders and to government officials that the BTL embedded in IECC-12 is too tight or at least that there will be builder pressure not to adopt this particular tightness limit.

This choice will push builders to employ building enclosure sealing technologies that will push the use of polyurethane spray foam insulation. This technology has proven problematic and could require greater regulatory oversight by DPS code officials.

This choice ensures that insufficient outdoor air will be required for new houses. This will lead to building-related illness in later years.

Choice 2 would be the same as Choice 1 but would add a requirement that whole-house mechanical ventilation include some form of energy recovery in the language adopting IRC-2012

This choice would ensure that the goal of IECC-12, energy savings, would actually be realized. Current technology to meet IRC-2012 only requires a fan and a control system. This would leave homeowners with the cost of moving outside air into a house but would cause the energy to condition that component of ventilation air to be much higher than were that air pre-conditioned by a recovery system.

The absence of this choice would lead to peak summer day sensible and latent loads to challenge or exceed air handler capacities in some houses. Energy would thereby not be saved because struggling air handlers would simply run longer or at higher compressor stages to compensate for the higher cooling load.

Choice 2 has a higher capitol cost than Choice 1. Some builders would object, for this reason alone.

Homeowners would realize lower energy operating costs but homeowners will not understand this fact.

Choice 3 would be to decide to adopt IRC-2012 but not to adopt an alternative and higher BTL than that now found in IECC-2012. One obvious alternative is to adopt 5 ach @50 PA, rather than the energy code value of 3 ach @50 PA.

This choice would solve the IAQ problem in that an exchange rate of 0.20 ach would permit sufficient outdoor air to meet the ASHRAE human health standard.

We'd save a bit less energy to accomplish this large benefit. Insofar as IRC-2012 requires mechanical air at and below this tightness level, we could also achieve the benefits of energy recovery if, along with Choice 3, we also adopted Choice 2.

Builders may find this choice easier to meet. Or, depending on the results of last year's blower door project, they may strongly object to this choice, on feasibility or cost grounds.

Choice 4 would be to retain the current BTL of 7 ach @50 PA (approximately 0.35 ach) and to decide to enforce it with a blower door test on every house.

The obvious disadvantage of this choice is that it does not secure the outdoor air energy savings of the other choices.

This choice makes mechanical ventilation a builder and buyer choice because it is greater than the whole-house mechanical ventilation requirement of other choices.

Choice of whether or not to build a mechanically ventilated house may have cost benefits to buyers, and therefore to builders. Whole-house mechanical systems impose serious capital costs, on the order of \$2,000 installed costs.

Indoor air quality can be achieved via natural or mechanical ventilation under this choice.